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# SCIENCE

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FRIDAY, NOVEMBER 18, 1898.

INERTIA AS A POSSIBLE MANIFESTATION OF  
THE ETHER.

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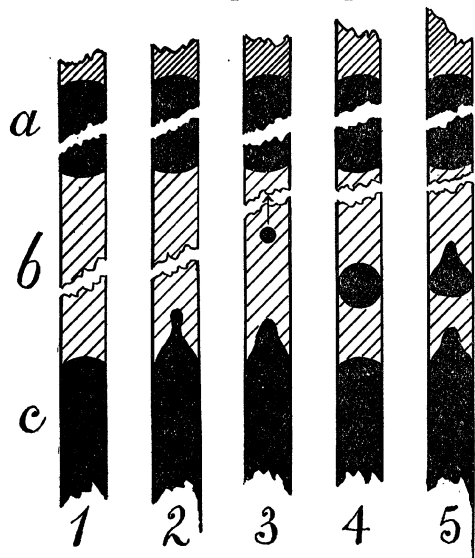
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MSS. intended for publication and books, etc. intended for review should be sent to the responsible editor, Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y.

IN the *American Journal of Science* for October I described certain experiments on the compression of coagulated jelly, to which I am inclined to attach some importance, since they establish a case of well defined persistent motion of material bodies in a highly viscous (solid) medium, as the sheer result of the breakdown of stress in the medium in question, and quite without the agency of any force 'acting at a distance.' I ask the reader's indulgence if I recall the main features of these experiments here, for the remarks which I propose to make in the present communication are to be based directly upon them and would lose their point in a mere reference.

Given a thread of firmly coagulated (10%–20%) gelatine solution *b*, Fig. 1, 10–20 cm. long, between terminal threads of mercury *a* and *c* in a fine bore ( $\frac{1}{8}$  mm.) strong capillary tube (not shown in figure). The upper thread is fixed; the lower is movable and transmits the pressure of a strong force pump. As pressure increases, it will be found that the originally convex meniscus in Fig. 1 is gradually more and more sharpened conoidally upward, until the unstable figure 2 is reached, after which, as in 3, a small projectile, usually round and often less than  $\frac{1}{16}$  mm. in diameter, is shot upward 10–20 cm., against gravity and against

the relatively enormous viscous resistance of the coagulated colloid. The motion of the projectile is extremely rapid at first (say several *met./ sec.*, or more), but gradually slows down, until after 5–10 minutes it has been reduced to the merest creeping visible in the telescope. This phenomenon



FIGS. 1-5

is repeated on increasing the pressure, but even at the same pressure many projectiles may be successively shot off to be distributed along the axis of the column. Later projectiles frequently actuate the earlier ones to renewed motion (5–10 cm.) without touching them and even after the latter have come to rest.

An interesting case is the *drop* of mercury purposely broken off ahead of the meniscus, as shown in Fig. 4, while the colloid was yet liquid. After thorough coagulation the effect of pressure is shown in Fig. 5. The drop soon takes a conoidal form,\* and thereafter shoots off projectiles of mercury from its apex, being continually replenished by bombardment from the meniscus below, changing form but remaining

\*The curvature due to stress is, of course, superimposed on the curvature of the globule.

in place. On another occasion, however, the drop deliberately exploded, being thereafter represented by some dozen small projectiles distributed through the lower 10 cm. of the colloidal column. The top meniscus neither moves nor changes form.

On gradually removing pressure the experiment is reversed, *i. e.*, the projectiles move in a somewhat similar manner back toward the (lower) meniscus out of which they originated. But the march back is not complete, showing that much energy is wasted in virtue of viscosity.

*Experiment explained.*—My explanation of these occurrences is as follows: The phenomenon throughout is elastic in character. The lower end of the colloidal column, loaded with a uniformly distributed pressure, yields like an elastic disc—least at the edges where it is sustained by the walls of the capillary tube and most near the center; for the jelly is not quite incompressible (compressibility of the order of about  $10^{-6}$  per atmosphere). The column is telescopically sheared, so to speak, and gives way symmetrically with respect of the axis. When stress exceeds the limits of rupture the strain breaks down, as indicated by the motion of the mercury projectile.

Consider the intrusion of the mercury globule for a moment; ahead of it there is always the continuous overstrained solid colloid; behind it discontinuous or triturated colloid, the debris of the original continuous column. The former transmits stress like a solid, locally showing definite rigidity; the latter transmits hydrostatic stress. So the projectile is pushed forward by rear-end pressure communicated by the mercury, but pushed forward at a gradually retarded rate; for, though the intensely viscous quasi-liquid not exactly

“...drags with each remove a lengthening chain,”

it must certainly make its way through an ever-lengthening channel, which eventually,

in fact, seals itself quite up again. The marvel is that the projectile gets so far after the first breakdown. It could not do so if the main part of its motion were not swift, indicating a very steep pressure gradient. At all events, the time soon arrives (5-10 minutes) when the elastic resistance of the strained colloid ahead of the projectile is in excess of the remnant of hydrostatic pressure behind it, and the projectile stops. It would gradually stop even without the recementation of the triturated channel, but the fact that the antics begin all over again with the next projectile is proof (were it needed) that the column has actually resumed continuity. It again gives evidence of definite rigidity.

Other things I would like to add, but I have already trespassed too far.

*The ether.*—Now, whenever one finds out anything about jelly—something of an order just a little above the kitchen I mean—one has the right to traipse in the footprints of well-known great thinkers and approach the ether. I am not given to denying myself, so I shall have my ether, which, just like the jelly, is to be solid or liquid under like conditions, as I please. Nobody ever caught such an ether before (though it has been fished for), which, to repeat, shall be either continuous and rigid or discontinuous, triturated, virtually rigid, as the conditions warrant. Note that since it *must* be elastic\* it may as well be *solid*, without invoking essentially new conditions.

Beyond this my ether is to have no respectable properties at all, except that if broken it seals itself up again, as all ethers do, particularly under pressure, and that it resists breakdown as this becomes more rapid. It is to be nearly incompressible, brittle, and in the first instance (by no means the last) free from inertia. Such

an ether can transmit stress instantaneously like a stick, or, better, like that imponderable instrument with which people poke fun at us. The ether cannot of itself vibrate. Though incompressible, it may become virtually so by enclosing triturated regions, particularly in the pressure of matter.

*The body.*—With these admissions, I will examine, for a moment, the relations of this ether to a physical body, regarded as a grouping of ultimate particles fixed relatively to each other. I shall use this body chiefly to produce the triturated regions, with a view to dropping\* it from the considerations *altogether*, if it can be made to appear non-essential.

Let there be given a region free from force. Let a body be imbedded in the solid (continuous) ether, permeating the region and permeating the body intramolecularly as well. In the first instance, inertia as a physical property is to be attributed neither to the body nor to the region.

Let the body be moved by an impulse from without. Immediately there will be discontinuous ether capable of transmitting hydrostatic pressure *behind* the body, or, better, behind each ultimate particle of the body, while the sheared continuous ether pervades in front of it, in the direction of motion.

Now, suppose that the trituration in question is a marked occurrence, accompanied, therefore, by increase of volume. There must then be a simultaneous manifestation of hydrostatic pressure in the triturated region greater, as the surrounding solid ether is more rigid.

*Regions of triturated ether.*—Now, consider the triturated region (however produced) by itself, supposing no material ultimate particles present therein.†

\*It is unfortunate that all ethers must be elastic. This really introduces the whole of our molecular machinery over again and indicates nothing ultimate.

\*The remarks in the *American Journal* refer to this body in place, in the manner set forth by the above text.

†I have also carried out these ideas, keeping the

As the case stands (no inertia), the region is the fund of the whole energy imparted by the impulse. In other words,  $\int pdv$  can not vary for the triturated region if no new impulse is at hand. But the ether, like the jelly, is supposed to be *self-sealing* under pressure; *i. e.*, the tendency to make  $\int pdv$  vanish. Hence, in homogeneous ether the triturated region, if alone, can not be at rest;\* it may either break down fresh continuous ether on one side as fast as it seals itself up again on the diametrically opposite side, always retaining  $\int pdv$  constant; or it may seal internally while it increases in area externally, forming an ever-widening closed shell whose energy per  $cm^2$  eventually obeys the orthodox law; if a body were present the region might become distributed among its vibrating molecules, etc.

*First law of motion.*—Now, as the breakdown progresses from layer to layer *successively*, the region will seal up soonest where it broke down first; for the pressure is constant throughout the region. Hence the motion of the region must be *uniform* and *linear* in the direction of the impulse. This seems to me to be an approach to Newton's first law. Rest, though impossible for a single region, may occur in a cluster of regions (see below), the individuals of which move.

Since energy imparted to the region in any other direction must act in the same way, I conclude that the new velocity may be compounded vectorially with the initial velocity.

*Second law of motion.*—The next question

body in place, with each of its ultimate particles associated with triturated ether, analogously to the mercury projectiles in the above experiment. But since my remarks can be made without reference to material molecules, I have preferred to drop the body (unwisely perhaps) as an unnecessary complication.

\* The rate of motion varies with the fineness of trituration, as will be indicated below; *i. e.*, it varies with the pressure in the region.

at issue is this: Can the region be made to behave like a massive body, even though made of stuff destitute of inertia. For ulterior reasons it is undesirable to change the volume of the region appreciably; any energy can, nevertheless, be stored within, by increasing the fineness of trituration. The effect of this is to increase the internal pressure and to increase proportionally, at the same time, the rate of recementation behind (in the direction of motion) and the rate of breakdown in front. Hence the region may be treated as moving faster in proportion as the energy imparted by the impulse is greater. Sealing is supposed to occur more rapidly under pressure, and the two rates must keep pace with each other if there is to be conservation of energy.

The resistance to increased breakdown would thus vary in the first place with the change per second of the velocity; for a regular succession of impulses, *i. e.*, a constant force, must produce a correspondingly regular succession of increments of velocity, or constant acceleration; it would vary in the second place with the total *front* of ether broken down. The latter quantity is thus left to account for mass. For simplicity let the regions occur clustered like the molecules of a body, and be all of the same spherical volume. Then the resistance to breakdown will vary, *caet. par.*, with their number per unit of volume, or, in other words, with the *density of distribution* of the regions within the body. This seems to be an approach to Newton's second law regarded as a manifestation of the ether.

A body built up of such similarly circumstanced regions would virtually be a massive body.\* Each component region, if not

\* The third law of motion, inasmuch as it deals with the occurrence of stress between two or more regions, must ultimately culminate in an explanation of gravitation. One naturally shrinks from touching this, though I hope to consider the reflection and collision of the regions at some other time.

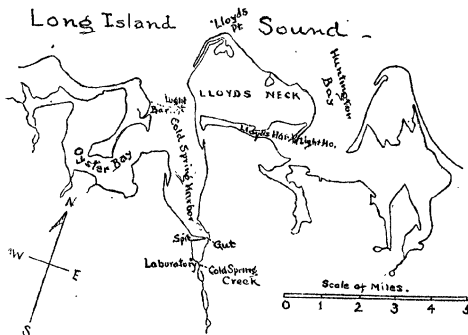
interfered with would maintain a constant rate of breakdown, implying constant velocity, as already explained.

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*THE FAUNA AND FLORA ABOUT COLDSPRING HARBOR, L. I.*

THE Biological Laboratory of the Brooklyn Institute of Arts and Sciences, located at Coldspring Harbor, Long Island, has during the nine years of its existence accumulated an important lot of information concerning the animals and plants of the vicinity. Especially during the present season has the attention of the investigators been in great part directed towards a biological survey of the locality. Of the survey the following may be regarded as a preliminary report.



The conditions at Coldspring Harbor are as follows: The Harbor is a body of water about five miles long and from one and a quarter miles to a quarter of a mile wide, which opens at its broader end into Long Island Sound, itself an inland sea, about eighty miles from where it debouches into the open ocean. Opening into Coldspring Harbor at about the middle of its western side is Oyster Bay, a tortuous body of water running back some six or seven miles and having a breadth varying from one and a-half miles to half a mile. Both Cold-

spring Harbor and Oyster Bay receive at their upper ends fresh-water streams of considerable volume, and at intervals along their coast line, smaller ones. Consequently the density of the water is low, being about 1.019 at flood-tide near the surface in the middle of the outer harbor. Coldspring Harbor is a sunken river valley with abrupt fiord-like sides, which extend back into the country for three miles from the upper end of the Harbor. In the valley runs the stream of Coldspring Creek, which expands at three different levels into broad, deep ponds, connected by waterfalls and shaded by dense foliage. The woods which rise from these ponds are densely grown with a rank vegetation and are rich in the fleshy fungi which accompany a moist climate.

Coldspring Creek, flowing, laden with silt, into the upper end of the Harbor, has formed there, with the aid of the sea, a sand spit which nearly cuts off an inner basin, about 3,000 feet long by 2,000 feet wide, from the outer harbor. The water of the inner basin is decidedly brackish, at high tide varying from 1.006 to 1.016 at the surface and from 1.006 to 1.018 at the bottom. The passage from the inner basin to the Harbor is only 200 to 300 feet wide at low tide, and through this 'gut' the water flows at times with great rapidity. The mean range of tide is 7.3 feet. The inner basin, which is gradually silting up, exposes about half of its bottom at every low tide for an hour or so. In the outer harbor, above the entrance of Oyster Bay, the water is uniformly 15 to 18 feet deep at low tide. Immediately below Oyster Bay entrance is a bar with only 6 to 10 feet of water at low tide. At the eastern end of this bar is a channel 72 feet deep. Outside the bar the water deepens steadily towards the middle of the sound.

The steep sides of the harbor are piles of glacial drift, full of clay, siliceous sand, gravel and boulders of varying size. This